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US Space Lift

Business of Space **Space Operations Scho**
5 Dec 2001

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US Space Lift

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US Space Lift Overview

- Space Launch Organizations/Facilities
- Space Lift Vehicles
- Upper Staging Devices
- Launch Process
- A Look Ahead
- Summary

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Air Force Space Command 14th Air Force

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- **Air Force Space Command**
  - Overall responsibility for space launch operations

- **14th Air Force**
  - Delegated day-to-day operational responsibility
  - Oversees the operation of the launch wings

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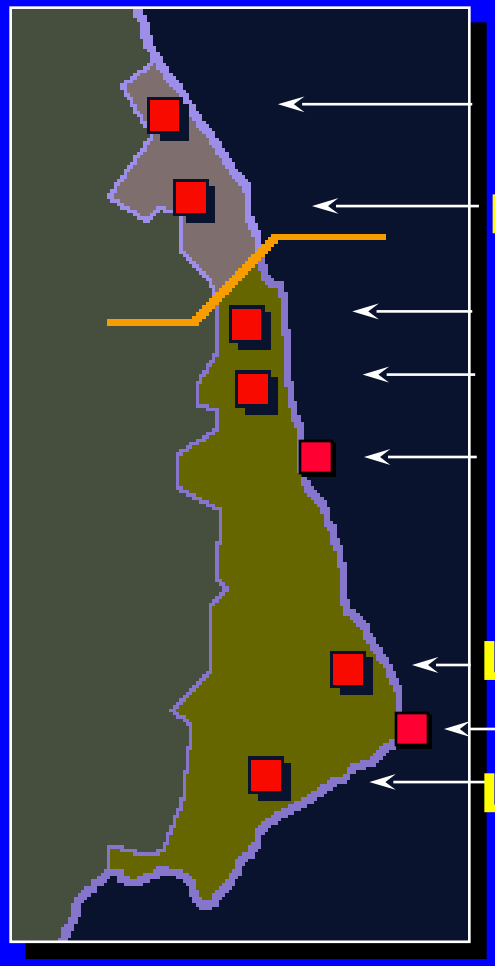
Launch Facilities - Eastern Range

45 Space Wing, Patrick AFB, FL

- **Complex Program**
  - 39 A/B — Shuttle
  - 41 — Atlas V
  - 40 — Titan IV
  - 37 — Delta IV
  - 36A/B — Atlas
  - 46 — Florida Spaceport
  - 17A/B — Delta II/III



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Launch Facilities
Western Range

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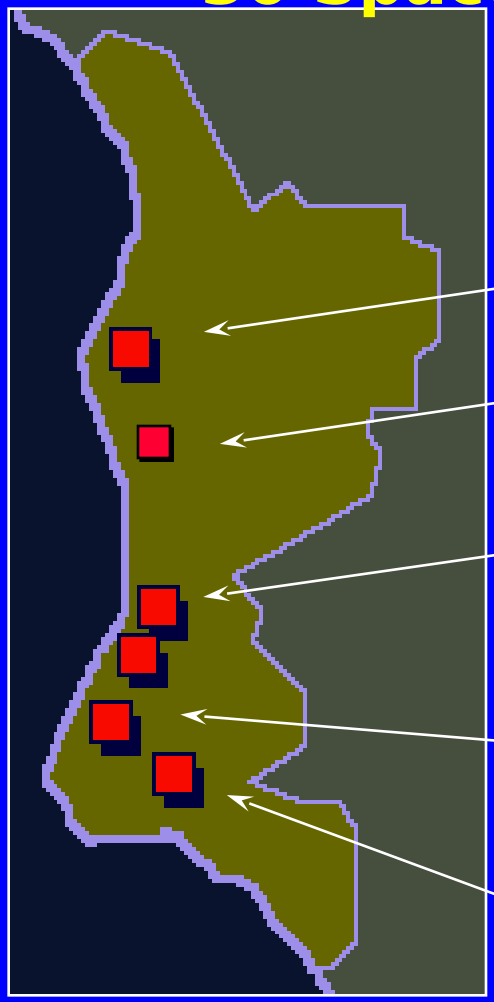
30 Space Wing, Vandenberg AFB, CA



Complex	Program
2W	Delta II
576E	Taurus
3E	Atlas II
3W	Inactive
4E	Titan IV
4W	Titan II
6	Delta IV

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Current Primary Launch Facilities

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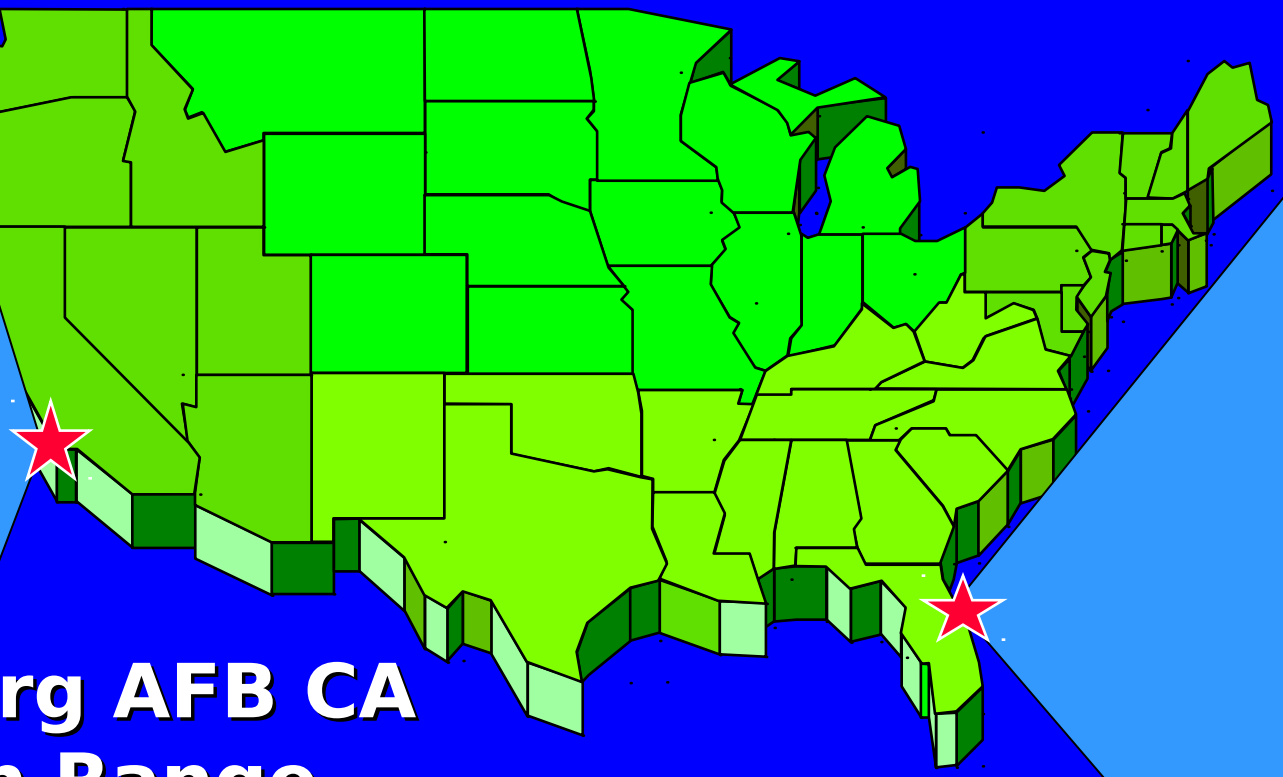

Vandenberg AFB CA
Western Range

Cape Canaveral AFS F
Kennedy Space Cente
Eastern Range

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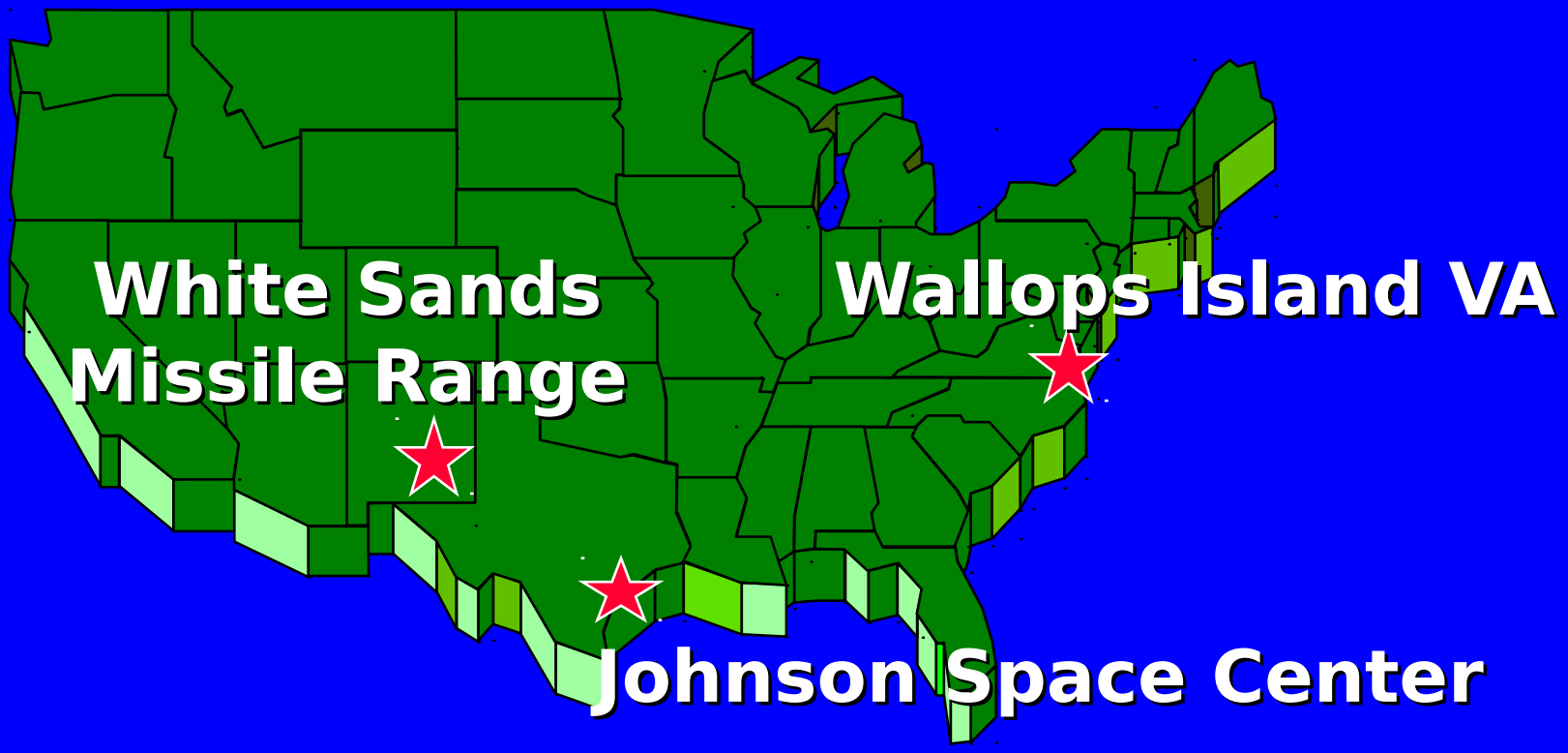
Other Organizations



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New/Future Launch Facilities

- California Commercial Spaceport
- Sea Launch
- Kodiak Island AK

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Space Support - Lift Vehicles

Delt

Atlas

Titan

Shuttle

Taurus

Pegasus

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Delta II

- Developed from Thor IRBM
- First DOD space launch - 1959
- Winner of Medium Launch Vehicle (MLV)
- I & III contracts (GPS Block 2 and 2R)
- 98.5% success rate (97/98)

Atlas 2 Series

- Commercial/DOD launch vehicle
- 4-6 launches per yr
- First launch - 12/93
  - 100% success rate
  - 55 for 55
- Launch site - Cape Canaveral
- Winner of MLV II contract

Titan II

- Refurbished ICBM
  - Deactivated in 1987
- Launch site - Vandenberg AFB, CA
- 100% success rate (22/22)
- 2-3 launches per year

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Titan IVB

- Configuration
  - Stretched two-stage core
  - Extended solid rocket motors
  - Upper stages
- Missions
  - DSP
  - MILSTAR
  - National programs
- First launched - Feb 97
  - 100% success rate (8/8) (booster)

DSP, Aug 6 '01

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Space Transportation System (STS)

- Designed as Aerospace vehicle
- Assured US access to space
- Launch site - Cape Canaveral
- First launch - Apr 81
- 8 launches per year

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Pegasus

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Pegasus

- Developed by Orbital Sciences Corp and Hercules Aerospace
- Three-stage, solid fuel
  - Optional fourth stage
- Missions
  - Small payloads to LEO
  - Store & forward communications satellites
  - Experimental satellites

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Pegasus

- First launch - Apr 90
  - Better than 85% success rate
- Formerly launched from B-52
- Now launched from L-1011
  - First L-1011 launch Jun 94

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Taurus

- Developed by OSC
- Four-stage, solid fuel
- Launch sites
  - Vandenberg AFB
  - Cape Canaveral AS
  - Mobile platform
- First launch - Mar 94
  - 80% success rate (4 for 5)
  - 1-2 per year

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Athena 1 & 2

- Formerly Lockheed Martin Launch Vehicle (LMLV)
- Based on Castor 120 solid rocket motor (1st stage and stage 2 on Athena 2 model)
- Two & three-stage, solid fuel
- Launch sites expected
  - Vandenberg AFB
  - Cape Canaveral AS
- First successful launch:
  - Aug 97

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Upper Staging Devices

- **Place heavier payloads into space**
  - **Inertial Upper Stage (IUS)**
  - **Payload Assist Module (PAM)**
  - **Transfer Orbit Stage (TOS)**
  - **Centaur**

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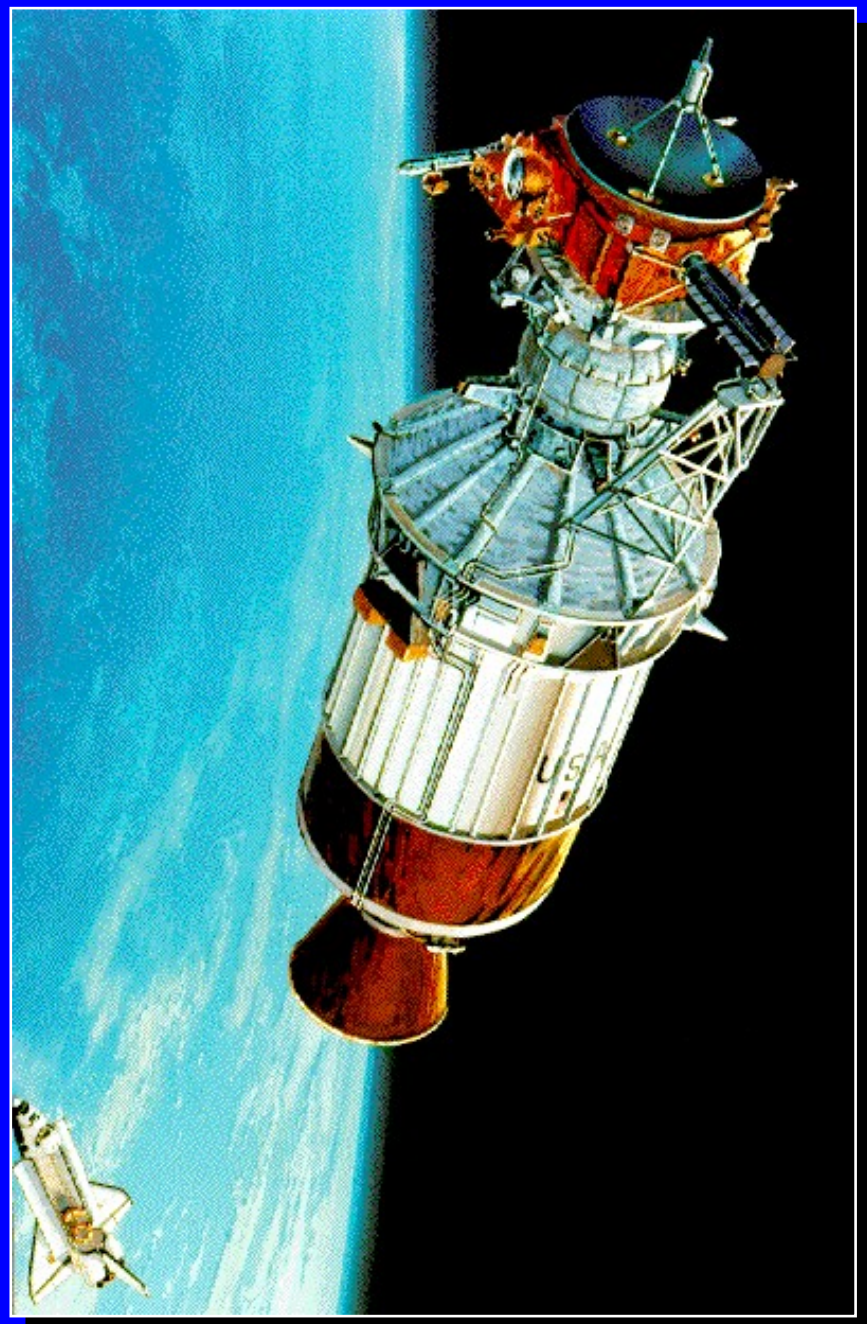
Inertial Upper Stage (IUS)

- Developer - Boeing
- Two-stage, solid fuel
- First flight - Oct 82
- Used with:
  - Shuttle
  - Titan IV



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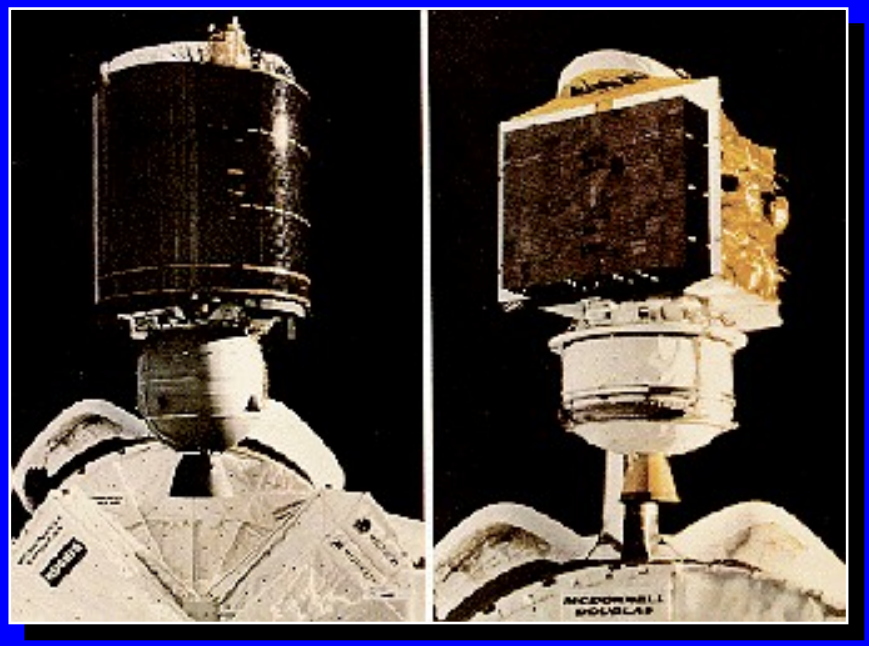
Payload Assist Module (PAM)

- Developer - McDonnell Douglas/Thiokol
- Single-stage, solid fuel
- First flight - Nov 80
- Used with:
  - Delta
  - Shuttle
  - Titan



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Transfer Orbit Stage (TOS)

- Developer - Orbital Sciences Corporation
- Single-stage, solid fuel
- First flight - Sep 92
  - Mars Observer
- Used With:
  - Shuttle
  - Titan 3 (Mars Observer)
  - Titan 4

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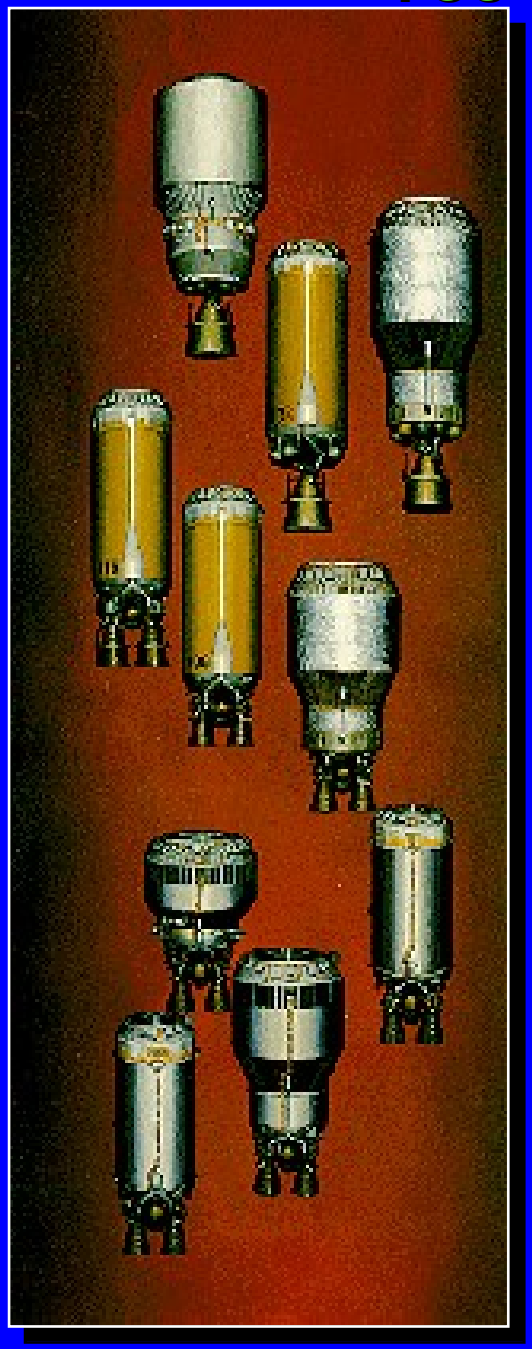
CENTAUR

- Developer - General Dynamics/ Pratt & Whitney
- Two-engine, liquid fuel
  - Cryogenic
- Used With:
  - Atlas 2
  - Titan IV



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Launch Process

- Pre-processing
- On-pad processing
- Integrated transfer launch
- Launch processing times

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Pre-Processing

- Payloads
  - Produced in facilities around the country
  - Shipped to launch location
  - Testing & checkout, integration with upper stage
  - Taken to launch pad

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Pre-Processing

- **Boosters**
  - Produced in facilities around the country
  - Shipped to launch location
  - Engine & avionics tests
  - Taken to launch pad for assembly & checkout

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On-Pad Processing

Delta Core Vehic

Graphite Epoxy Motor Processing

Final Payload Processing

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Integrated Transfer Launch Cape Canaveral AS

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Vertical Assembly Building

Solid Motor Assembly and Receiving Facility

Payload Assembly

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Launcher Processing Times

System	Interval (days)
Atlas	58-62
Delta	70
Titan II	114
Titan IV	165
Shuttle	70
Pegasus	45
Taurus	10*

* advertised

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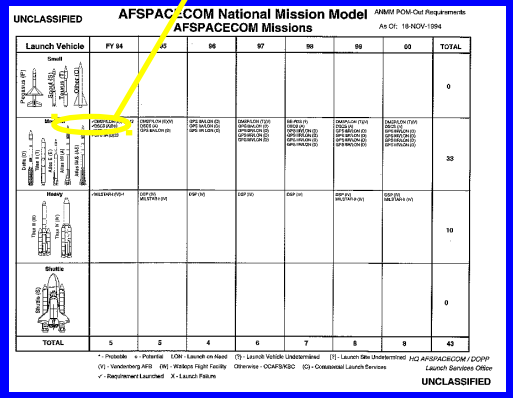
Constellation Sustainment

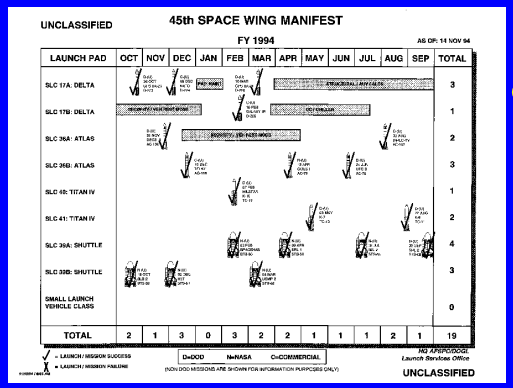
- **Launch on Predicted Failure**
  - **Replace satellites based on historical failures**
  - **Satellite is degraded or showing signs of imminent failure**

Deployment

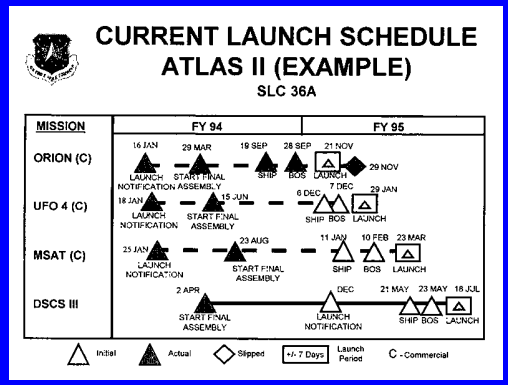
DSCS III



NATIONAL LAUNCH FORECAST 8 YEAR FORECAST



SPACE LAUNCH MANIFEST 3 YEAR FORECAST



CURRENT LAUNCH SCHEDULE 18 MONTH EXECUTABLE

Launch to Augment

- Increases constellation beyond Operational Requirements Document to meet contingency needs

- Normally an acceleration of the launch schedule
- Replacement satellite and boosters must be budgeted
- Extremely expensive to accelerate booster and satellite production
- May need to “preempt” another launch

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Future US Launch Vehicles

- Atlas III
- Delta III
- EELV
- X-33
  Cancelled
- Minotaur

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Lift Performance

Vehicle	LEO	Polar	GTO	G
Pegasus	900	600	440	
Athena 1	1,750			
Taurus	2,750	2,050	725	
Athena 2	4,350			
Atlas 2A	15K		6,100	
Shuttle	32-55 K			13K
Titan IVB	48K	39K		13K
Titan 2		4,800		
Atlas III			9,920	
Delta III	18K		8,400	
Minotaur				
Delta IV	18-51K		9-29K	
Atlas V			19K	1

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US Boosters Capacity (Cost)

Vehicle	Cost ($M)	Lift to LEO (lbs)	Cost per lb
Pegasus	10.5-13.4	814	$14,000
Taurus	18-22	3,000	$6,800
Delta II	40-50	11,110	$4,275
Atlas II	80-90	15,700	$5,414
Titan IV	170-230	39,000	$5,128
STS	350-547	53,700	$8,352

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